Technical Bulletin: Industry 4.0 in the plastics sector.

POLINTER

1 Introduction

1.1 Evolution of the industry

In the industrial sector, it was first known about the power of steam and water with the steam engine; then came electricity and fossil fuels; then automation ... so what comes next? Currently it is in the middle of a fourth wave of technological advances in the industrial sector: the emergence of the new digital industrial technology known as Industry 4.0, also called Fourth Industrial Revolution, smart industry, factory of the future, cyber-industry of the future, revolution 4.0, industrial internet of things, among other names.

This is how this new revolution proposes to connect machines, systems and people in production processes, through the combination of cyber-physical systems, the Internet of Things (IOT) and the Internet of Systems. These connected systems will make it possible to collect and analyze data between machines, enabling faster, more flexible and efficient processes to produce higher quality products at a reduced cost.

Industry 4.0 is on its way and is having an impact on all industries, and especially the plastics industry, through modern machine innovation that points towards data sustainability, integration and interconnection.

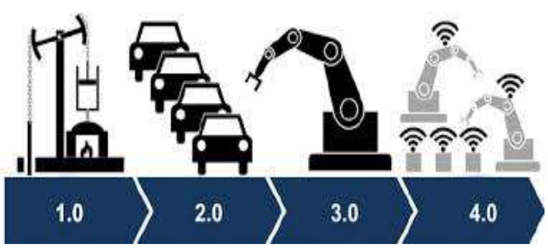

Fig. 1. Industry evolution

In the **First Industrial Revolution (1.0)** between 1760 and 1830, the first steam engine was built. This invention marks the beginning of a shift from manual labor to mechanization of production. Merchandise storage required product-by-product movement, since warehouses were simple spaces to store raw materials or finished products.


Fig. 2. Steam machine. First Industrial Revolution

The introduction of electricity and oil at the beginning of the 20th century ushered in the **Second Industrial Revolution (2.0)**. The mechanical hydraulic and steam traction systems gave way to the electrical ones, which led to series production and the division of labor. Warehouses were transformed with the introduction of modern tools, such as the forklift or automatic production lines. This revolution was characterized by the development of the chemical and petrochemical industry, which was born with the creation of the first synthetic plastic (Bakelite), among others.


Fig. 3. Serial production. Second Industrial Revolution

In 1969, the programmable logic controller was introduced, the first computer used for industrial automation of electromechanical processes. This invention marks the beginning of the Third Industrial Revolution (3.0), allowing different tasks to be programmed for a machine. The development of the programming allowed to reduce costs and increase the capacities of the industrial robots that transformed the production lines.

In the **Third Industrial Revolution** there were great changes thanks to the use of electronics and computers to develop automated processes, allowing to include levels of precision and accuracy. In turn, the use of renewable energy, the automation of processes and the use of the internet were incorporated.

Fig. 4. Industry automation. Third Industrial Revolution

At the end of the 90s and during the first decade of the new millennium, access to the Internet accelerated the third industrial revolution, but it was not until the appearance of the first smart products (which allow the mobile connection between products and people), that it is considered the beginning of the Fourth Industrial Revolution.

The **Fourth Industrial Revolution (4.0)** is still in development and aims to take the automation of manufacturing processes to a new level, by introducing flexible and customized mass production technologies. Here the machines become an independent entity that can collect data, analyze it and manage it.

"Industry 4.0" is the term coined by the German government to describe the smart factory, a vision of computerized manufacturing with all processes interconnected by the "Internet of Things" (Internet of Things - IOT, for its acronym in English).

Fig. 5. Industry digitization.

1.2 Current situation of the plastics industry

Today, the plastics industry is reasonably fragmented; Although automation is a process that is present in most plastics factories, not all existing equipment in the industry can be defined as 4.0.

However, the plastics industry has not been left out of this concept and technology manufacturers, mainly European, have been following developments to adapt to changes and be part of the industrial future. Energy savings, materials and resource efficiency, smart, fast and flexible production lines, as well as innovative recycling concepts and new application areas for the manufacture of additives and organic plastics are some of the advances that are being made. have given in the plastics industry. Most of the innovations and improvements seek to reduce waste, energy consumption in the production process, the weight of molds and parts and, consequently, the environmental impact.

2 THE FACTORY OF THE FUTURE

Like other Smart equipment, the smart industry will be a network in which each of the elements that constitute it will be communicating with each other to create what is known as Cyber-Physical Production

Systems (CPS). Cyber-physical systems aim at the digitization, integration and automation of computing and physical processes.

The upgrade to industry 4.0 requires extensive knowledge in various specific fields, so it is of great interest to understand and become familiar with the new concepts and terms that make up this new industrial era.

Within the new technologies there are two groups:

- Physical: these are the technologies that will have a tangible character such as additive manufacturing, robotics, smart codes, smart devices, among others.
- Digital: They are those that understand the technologies derived from the Internet of things, big data, cloud, among others.

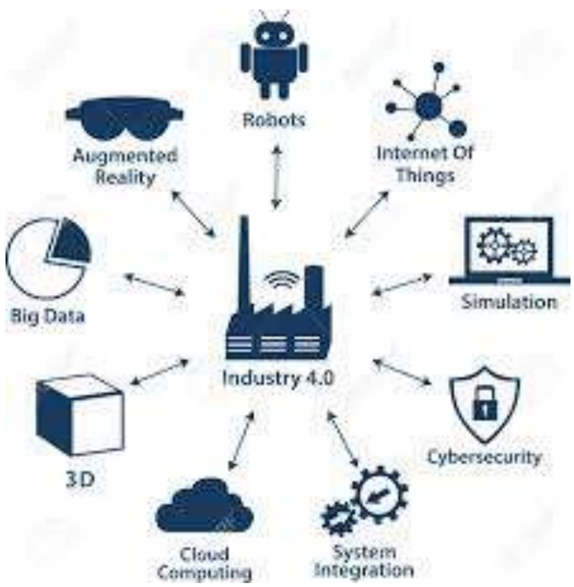

Fig. 6. Smart Industry Components

·Physical

Equipos ciber físicos

Smart machines have the ability to process large amounts of data and exchange it with other computers. In the plastic industry, plastic injection machines are being developed focused on a data control system, where all the information of the process (peripheral devices, robots, production, quality) is gathered, to monitor and allow the equipment to be self-adjusting.

Collaborative robotics and flexible manufacturing

Collaborative robots (cobots) help operators, freeing them from repetitive, exhausting or dangerous tasks. Artificial intelligence, in robotics, describes the ability to react appropriately to unforeseen non-scheduled situations.

In the packaging industry, for example, a robot that receives a product that deviates from the standard in terms of geometry or shape can identify it and react accordingly. Another application of robots in the plastic industry is the fast and precise handling of injection molds, for the creation of short production series such as the transfer of hot parts, the loading and unloading of machines and verification of burrs.

Among the benefits of cobots in the plastic industry are:

- ✓ Flexibility: adaptation to different production tasks.
- ✓ Safety: avoid worker exposure to dangerous tasks.
- ✓ Increased production: they have a high degree of repeatability and precision.

Fig. 7. Collaborative robot

Additive manufacturing

3D printers are machines capable of replicating designs in three dimensions, creating pieces or volumetric models by successive layers from a computer-aided design, downloaded from the internet or collected from a scanner. 3D printing allows cost savings and increased product quality.

Fig. 8. Stratasys brand 3D printer

[taken from the Applications department - INDESCA]

2.1 Digital

Internet of Things (IOT)

The *Internet of Things* is an important point in the construction of Industry 4.0, since, when referring specifically to processes and manufacturing, it goes hand in hand with the interconnection between machines and programs to generate automated processes. One of its objectives is to adapt production to consumer needs in real time.

There are three concepts to consider for the industrial internet:

- Smart machines as new ways to connect and improve processes through advanced sensors, controls, networks and software applications.
- Advanced analysis based on automation, physics, administration, among others, to understand the operation of large systems and companies.
- People connected to the industrial sector at any time.

Consequently, IOT allows machines and sensors to communicate with each other, making objects work and solve problems autonomously.

With the industrial internet of things, more devices will be enriched with the information they can send and will be interconnected with different teams, decentralizing the analysis of information and decision-making.

In this way, data storage and analysis can be used to improve machine performance and the efficiency of systems and processes, as well as the customer experience.

Fig. 9. Interconnection of machines and people

Cyber Security

Due to the fact that large amounts of information are handled through public networks (via the internet) and private (via intranet) of companies, it is necessary to maintain the highest information security to avoid the entry of viruses and the plagiarism of information.

The cloud

It is about instant access at all times of data or information through the internet. There are already companies that manage software in the cloud, so with the arrival of these technologies to industrial plants, companies require a greater exchange of data between the different areas without depending on the physical storage systems of the machinery or the teams in the business systems area.

Big Data

It is a data analysis technology that together with machines and intelligence offer important functionalities, in addition to storing and processing processes in real time basically from the "cloud" or the web.

Fig. 10. Cloud storage

3 INDUSTRY 4.0 DESIGN PRINCIPLES

The design of this industry will allow manufacturers to investigate a possible transformation towards Industry 4.0 technologies.

The principles of this design are:

- ✓ Real-time capacity. Collect data, store, analyze and make decisions in real time.
- ✓ Virtualization. CPS must create a virtual copy of the entire process.
- ✓ Decentralization. CPS ability to work independently.
- ✓ Service orientation. Internet connection of services to create products according to customer specifications.

4 BENEFITS AND SOLUTIONS OF INDUSTRY 4.0 TO THE PLASTIC SECTOR

Through the implementation of Industry 4.0 concepts, significant investment benefits can be obtained. Early forecasts indicate an estimated revenue increase of more than 30% and cost reductions of more than 30%.

4.1 Processes and resources

From a process point of view, the new technologies aim to reduce energy by up to 30% and shorter operating times, with reductions of up to 50%. There are injection machines, for example, that provide injection speeds up to 1000 mm / sec.

4.2 Use of assets

The possibility that the machinery supports changes and automation in operations, capable of being carried out without requiring complex adjustments, facilitates adaptation and response to the market, thanks to the reduction (30-50%) of downtime.

For its part, predictive maintenance allows anticipating when an equipment failure could occur, preventing its occurrence by performing maintenance in a timely manner, thus eliminating the causes of systemic failures.

4.3 Sustainability

The contributions that the sector has made with the inclusion of cleaner processes with respect to the environment, reusing raw materials, stand out. An example of this is the manufacture of plastic injection molding machines, blow molding and other peripheral equipment, which can use recycled plastics as raw material.

4.4 Human capital

The adoption of new technologies will have an impact on the education and training of the workforce. Work automation is the use of computers to perform tasks that depend on complex analysis and creative problem solving, without fatiguing staff and allowing the use of their knowledge to be redirected.

4.5 Inventories

New technologies tend to reduce inventories by 50-80%, by optimizing the supply chain in real time.

4.6 Quality

Quality deficiencies caused by unstable manufacturing processes, poor packaging in the supply or distribution chain are eliminated. A decrease in non-optimal quality of between 10-20% is achieved. In addition, statistical control is included, through an exponential increase in available data and statistical techniques, which will allow the industry to reach new levels of efficiency in matters such as, for example, the reduction of defective parts, making it possible for many companies to reach category 6 sigmas, without large investments.

4.7 Market adjustment

Finally, Industry 4.0 allows the adjustment of supply to existing demand. The availability of real-time data, including market trends, weather, among others, will allow a more accurate prediction of customer demand.

Furthermore, simulation tools are the best allies right at the beginning of a product's life cycle. With them, it is possible to drastically reduce development times and make it possible, from the 3D design phase, to modify the properties of a product.

5 CHALLENGES FACING INDUSTRY 4.0

The smart industry faces challenges that it must overcome as:

- Security: cyber theft is a latent threat with data leaks, hackers and failures, so it is essential to find solutions that protect data, connections and virtual infrastructures.

- Capital: changing a new technology requires a large investment. The current question is to know the percentage of companies that have sufficient investment and management capacity for transformation.

- Privacy - In such an interconnected industry, manufacturers need to collect and analyze data. For the customer it could appear a threat to their privacy. Work must be done to achieve a more transparent environment.

- Employment: Undoubtedly, digitization will create new highly qualified jobs in the areas of planning, configuration and maintenance of new technologies. However, low-skilled workers may be affected. However, there may be ergonomic improvements in workers as repetitive tasks are taken over by robots. That is why workers will have to quickly acquire new skills to take on smart factories.

6 EQUIPMENT, MACHINERY AND PROCESSES IN THE PLASTIC INDUSTRY

Under the concept of "Industry 4.0", it offers greater automation for quality control and lower costs through the reduction of cycle times and product weight controls. The new equipment has systems to monitor production and maintenance, as well as the most important variables that can cause product defects.

6.1 Extrusion

At present, the manufacture of twin screw extruders stands out, with an increase in production capacity of up to 20% and a reduction in energy consumption by 15%. They are also equipped with advanced sensors that support diagnostic capabilities for preventive maintenance planning and monitoring of product quality parameters.

6.2 Blowing films

A new cooling ring technology for film extrusion is available, increasing the performance of blown film extrusion by up to 60%. An example is the Addex ICE Cooling System which consists of a series of cooling rings placed in a stacked configuration to achieve higher efficiencies. Each air ring directs a divergent airflow along the bubble, both up and down, from each stacked cooling element.

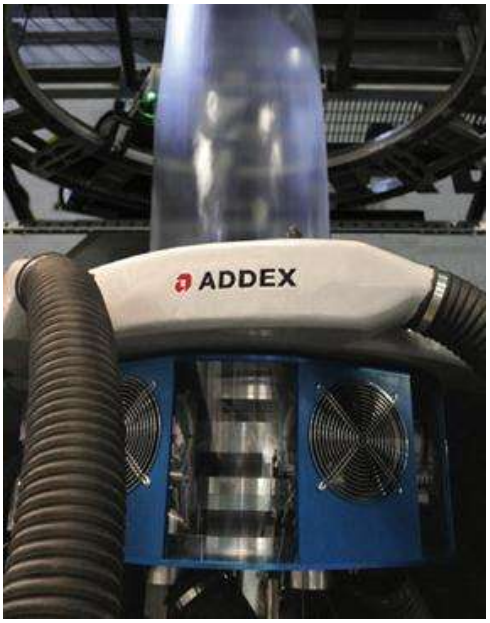

Fig. 11. Addex ICE cooling system

[taken from the technical bulletin: Feria K 2016 - INDESCA]

Another technology is the automation of flat extrusion heads, to increase the stroke of the lip adjustment system by 43%, in order to allow the correction of process variations without the need for manual intervention.

6.3 Inyection

The large and recognized manufacturers of injection machines present self-regulated and interconnected systems between machines and components. An example is *Engel's* 4.0 injection machine, which is automatically optimized thanks to the interconnection and integration of production systems and the use of process data. The intelligent control system analyzes operating parameters such as plasticizing time, temperature profile, pressure profile, cooling and mold release to guarantee product quality. In turn, it works with software that provides an overview of the entire process.

Fig. 12. Engel injection machine

[taken from the Plastimagen 2016 fair].

7 POLINTER AND INDUSTRY 4.0

Polinter, with the support of Indesca, has been working in the last decade in the development of Industry 4.0, in what corresponds to the production of PE articles in Venezuela. Thus, for example, it has participated in the generation of prototypes through 3D printing, obtaining samples - on a small scale - of the designed products, to study the convenience of maintaining or modifying their geometry before transformers make large investments in industrial equipment molds.

Such is the case of rotomolded desks[9.15], development of Polinter together with the company Q 'Productos, with which it obtained the "Single Part Design" award in the International Plastics Design Competition, held in Chicago, United States, within the framework of the exhibition of the National Plastics Exhibition (NPE) and the ANTEC (Annual Technical Conference) of the Society of Plastic Engineers (SIP), in 2009.

Fig. 13 Desk prototype created by 3D Printing at Indesca

Another example of the use of technology is the development of a selector, which allows predicting the properties of plastic films [9.13]. This study is related to "Big Data" data storage adapted to graphical interface and mathematical equations, which allow users to anticipate the resulting properties in plastic films made with Venelene® grade resins.

8 CONCLUSIONS

The concept of ***Industry 4.0*** seeks the best integration of automated processes, through the interconnection of their equipment, in order to reduce operating costs and add value to the finished product. These technologies are made up of: simulation, robotics, integration systems, internet, cybersecurity, the cloud, Big Data, 3D printing, among others.

Intelligent assistance enables a much broader range of applications with the use of automated information, data evaluation, real-time monitoring, and analytical capabilities to drive efficiencies in operational assets. She gives manufacturers the ability to initiate knowledge-based systems, to improve processes and optimally use people and machines.

The plastics industry, like others, considers the options available in the market and adapts to new technologies, as an opportunity to grow and increase the possibilities for the future, in order to satisfy customer requirements and be more competitive.

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